Chapter 6. EMISSION REDUCTIONS, AIR QUALITY, VISIBILITY AND COST IMPACTS

6.1 Results in Brief

The final regional haze (RH) program is designed to ensure reasonable progress toward visibility goals that States and/or regional planning boards may set. It allows broad discretion on the part of the States in determining control measures to be imposed based on statutory criteria. Under the structure of the final RH rule, the States are able to consider the cost of emission reduction strategies in light of the degree of visibility improvement to be achieved. For this Regulatory Impact Analysis (RIA) the individual decisions on effectiveness of each of the control strategies applied in each region is modeled in a very limited way. With more time and better emissions inventories, better characterization of the emissions, better air quality relationships, technological change, and the ability to consider other visibility progress goals, the actual cost of implementation may be less than what is presented in this RIA. It is expected that the incremental control costs (and also the benefits and economic impacts) of the final RH rule may be less than estimated in this RIA. There may be some positive incremental costs of the RH rule as a result of administrative activities (e.g., planning, analysis, etc.) and Best Available Retrofit Technology (BART) controls for some establishments in certain source categories. The administrative costs are shown in Chapter 7, and a presentation of costs associated with BART controls is available in Section 6.6.3.

It should be noted that there is substantial progress towards these illustrative RH goals in the analysis year 2015[1] resulting from partial attainment of the particulate matter (PM) and Ozone NAAQS promulgated in 1997 including the Tier II version described in Chapter 5 that is in the baseline for the RH rule. There is also additional progress toward these illustrative goals from implementation of the other control measures in the baseline for the RH rule (the 60 percent control of sulfur dioxide (SO_2) beyond Title IV requirements, listed in Chapter 5 of this report). From 46 to 55, or 38 to 45 percent, of the Class I area counties meet the two absolute illustrative RH progress goals considered in this RIA based on implementation of the control strategies in the benchmark case. From 27 to 47, or 22 to 39 percent of the Class I area counties meet the two relative illustrative RH progress goals considered in this RIA based on implementation of the control strategies in the baseline case. It should also be noted that among those Class I area

[1] 2018 is the end of the period for the first long-term strategy. The term "long-term strategy" refers to the set of emission reduction measures the State includes in its SIP in order to meet the reasonable progress goal it has set. 2015 is a nominal "snapshot" year that reflects the partial attainment control cases for the Ozone and $PM_{2.5}$ NAAQS included in the baseline, and is near the end of the period for the first long-term strategy.

counties not meeting the illustrative RH progress goals, few of them are expected to be more than 0.2 deciview away from the illustrative goal.

Based on projected emissions levels for the year 2015, and with partial attainment of the Ozone and particulate matter ($PM_{2.5}$) National Ambient Air Quality Standards (NAAQS) as modeled in the 1997 RIA for the final 8-hour Ozone and $PM_{2.5}$ NAAQS and proposed RH target program (henceforth referred to as the "1997 RIA") in the baseline, and for emissions control cases in which fugitive dust controls are considered or not (Cases A and B), this analysis estimates that 19 counties having Class I areas under Case A need additional emission reductions to meet the illustrative progress goal of 1.0 deciview (dv)/10 years for the period of the first long-term strategy. This analysis also estimates that 32 counties having Class I areas under Case B need additional emission reductions to meet the same illustrative progress goal for the period of the first long-term strategy. This analysis also estimates that under Case A 12 counties having Class I areas need additional emission reductions to meet the illustrative progress goal of 1.0 dv/15 years for the period of the first long-term strategy (i.e., an average of a 0.67 deciview improvement from benchmark air quality conditions), and this analysis estimates that under Case B 19 counties having Class I areas need additional emission reductions to meet the same illustrative progress goal for the period for the first long-term strategy.

In response to comments on the proposal RH RIA, this final RH RIA also looks at two relative illustrative progress goals. These goals are defined in Chapter 3 of this RIA. Based on projected emissions levels for the year 2015, and with partial attainment of the ozone and $PM_{2.5}$ NAAQS as modeled in the 1997 RIA in the baseline, and for emissions control Cases A and B, this analysis estimates that 68 mandated Class I areas under Case A need additional reductions to meet the illustrative progress goal of 10% dv/10 years for the period of the first long-term strategy. This analysis also estimates that 83 counties having Class I areas under Case B need additional reductions to meet the same illustrative progress goal for the period of the first long-term strategy. Finally, this analysis also estimates that under Case A that fourteen counties having Class I areas need additional reductions to meet the illustrative progress goal of 5% dv/10 years for the most impaired days from for the period of the first long-term strategy, and this analysis estimates that under Case B 21 counties having Class I areas need additional reductions to meet the same amount of visibility improvement for the period of first long-term strategy.

The additional cost of any implementation of the illustrative RH progress goals will vary depending on the visibility goals submitted and approved as part of State plans. If the goals are adjusted through that process to parallel the implementation programs for the new Ozone and PM standards, the costs for meeting the adjusted goals in those areas will be borne by the Ozone and PM programs. In this analysis, incremental costs are estimated for uniform application of the illustrative progress goals for every mandatory Class I Federal area under either Case A or B.

For the two absolute illustrative progress goals, the additional control cost associated with meeting the progress goal of 1.0 dv/10 years in 56 counties having Class I areas, while partially meeting the progress goal in another 19 counties is estimated to be $1.7 billion (1990 dollars) under Case A. Under Case B, the additional control cost associated with meeting the same progress goal in 43 counties having Class I areas while partially meeting the same progress goal in another 32 counties is estimated to be $1.4 billion (1990 dollars). The additional control cost under Case A associated with meeting the illustrative progress goal of 1.0 dv/15 years in 54 counties having Class I areas while partially meeting the goal in 12 counties is estimated to be $1.1 billion (1990 dollars). Under Case B, the additional control cost associated with meeting the illustrative progress goal of 1.0 dv/15 years in 47 counties having Class I areas, and partially meeting the goal in 19 counties is estimated to be $0.8 billion (1990 dollars).

For the two relative illustrative progress goals, the additional control cost under Case A associated with meeting the goal of 10% dv/10 years in twenty-six counties having Class I areas while partially meeting the goal in 68 counties is estimated to be $4.4 billion (1990 dollars). Under Case B, the additional control cost of meeting this same illustrative progress goal in eleven counties having Class I areas while partially meeting the goal in 83 counties is estimated to be $3.6 billion (1990 dollars). The additional control cost under Case A with meeting the goal of 5% dv/10 years in 60 counties having Class I areas while partially meeting the goal in fourteen counties is estimated to be $1.5 billion (1990 dollars). Under Case B, the additional control cost with meeting this progress goal in 53 counties having Class I areas and partially meeting the goal in twenty-one counties is estimated to be $1.2 billion (1990 dollars).

In summary, the expected annual control cost nationwide in 2015 associated with the RH illustrative progress goals ranges from between $0 to a maximum of $4.4 billion under Case A, and from between $0 to a maximum of $3.6 billion (1990 dollars) under Case B. A comparison to the RH targets (now called absolute illustrative progress goals) analyzed for the proposal RH program shows that the additional control costs are estimated to be about 40 percent less than before under Case A, and more than 50 percent less under Case B. The number of Class I areas that can meet the 1.0 dv/10 years illustrative progress goal increases under Case A (28 v. 19) relative to the estimate given for proposal, but decreases under Case B (28 v. 32). In addition, the number of Class I areas that can meet the 1.0 dv/15 years illustrative progress goal also increases under Case A (17 v. 12) relative to the estimate given for proposal, but decreases under Case B (17 v. 19). The ability of the air quality modeling to account for the contribution of VOC and PM controls to improved visibility (as explained in Chapter 4) is the primary reason for the lower control cost estimates for these goals under either emissions control case. The exclusion of fugitive dust controls from the least-cost optimization for these goals also leads to lower additional control costs but also fewer counties having Class I areas able to meet the illustrative progress goals. This reflects the differences in the post-control air quality profiles that results from removal of the fugitive dust control measures. A list of these control measures is in Chapter

5.

The estimates of the incremental cost of illustrative progress goals are also affected by: 1) an analysis baseline that understates the visibility progress achieved by CAA mandated controls and implementation of a new Ozone standard over the period of the first long-term strategy; 2) the inability to accurately model full attainment of the 8-hour Ozone and $PM_{2.5}$ NAAQS in the baseline; and 3) how close some of the residual Class I area counties are to natural background conditions. These factors suggest that the actual cost of achieving visibility improvements incremental to the baseline for this report could be lower.

It should be noted that direct quantitative comparison of the cost results for Cases A and B is not warranted due to the difference in the number of counties having Class I areas that are not able to meet the illustrative RH progress goals. However, it does suggest the importance of improved emission inventories, air quality modeling, and the concomitant control strategy design.

6.2 Introduction

This chapter presents the air quality and visibility improvements, emission reductions, and cost impacts resulting from additional controls needed by the year 2015 to meet the illustrative RH progress goals under emissions control Cases A and B presented in Chapter 3. Emissions and air quality changes are inputs to the benefits analysis presented in Chapter 9. This analysis also estimates the projected costs (in 1990 dollars) of installing, operating, and maintaining those additional controls needed by the year 2015 to meet the illustrative RH progress goals in our nation's Class I designated areas. These control costs are inputs to the economic impact analysis presented in Chapter 8. The administrative cost associated with these illustrative RH progress goals is addressed in Chapter 7.

The following sections in this chapter cover:

- Methodology for estimating emissions, air quality, and cost impacts associated with the illustrative RH progress goals;

- Emission reduction, air quality improvement, and control cost results associated with the illustrative RH progress goals; and

- Analytical uncertainties, limitations, and potential biases for these results.

6.3 Emissions, Emissions Reduction, Visibility Improvement, and Cost Methodology

This analysis estimates the emission reductions for achieving air quality improvements to meet the illustrative RH progress goals described in Chapter 3 in Class I area counties that are projected to not meet these goals. Since Class I areas rarely contain emissions sources, and because pollutants that degrade visibility can be transported over long distances by prevailing winds, controls must be imposed on sources located outside of Class I areas that contribute to visibility degradation in Class I areas.

The baseline for the RH analysis is the projected emissions inventory from the partial attainment case of the Ozone, PM_{10} and $PM_{2.5}$ 15/65 NAAQS presented in the 1997 RIA, which includes a modest version of the Tier II program described in Chapter 5 of this RIA. The emissions control possibility set includes measures that are not already selected in that analysis.

The projected end of the period of the long-term strategy for achieving and evaluating visibility improvement is 2018. In order to evaluate visibility improvements, visibility monitors must be established in the Class I areas of concern, and it is likely to take a few years to establish these monitors. Ideally, this RIA would evaluate the potential improvements in visibility for the period of the first long-term strategy, and would account for emission reductions achieved from current CAA-mandated controls (e.g., Title IV SO_2 cap on utility sources) and the promulgated $PM_{2.5}$ and Ozone NAAQS (including the modest version of the Tier II program in the RH baseline). However, this requires developing an emissions inventory current as of the first year of the long-term strategy period and a set of control measure impacts incremental to the first year of this period. Instead, the RH analysis takes advantage of the 2010 emissions inventory and incremental control measure database established for the $PM_{2.5}$ and Ozone analyses conducted for the 1997 RIA.

Control costs for attaining the illustrative RH progress goals are evaluated incremental to partial attainment of the current PM_{10} NAAQS, and the current Ozone and $PM_{2.5}$ NAAQS (including the modest version of the Tier II program in the RH baseline). If a Class I area is projected to meet the illustrative progress goals in the year 2015 as a result of ozone and $PM_{2.5}$-related control measures (i.e., baseline control measures), no additional control is needed. However, if the goal is not met, additional control measures are modeled. This baseline provides conservative estimates (i.e., potentially overstates) of the cost of achieving RH progress goals for two reasons. First, the progress achieved by measures related only to $PM_{2.5}$ control through the year 2015 does not include progress achieved due to measures already mandated under the 1990 CAA, or progress achieved due to controls needed to meet the new Ozone standard. These control measures, which are not in the baseline of the RH analysis, may contribute to further visibility improvement over the period of the first long-term strategy. Second, applying the set of control measures included in the $PM_{2.5}$ NAAQS analysis in the 1997 RIA results in residual nonattainment for some areas. To the extent that these areas are actually able to achieve additional reductions to attain the $PM_{2.5}$ standard, further visibility improvements may also be realized.

The 2010 baseline air quality reflective of CAA-mandated controls and additional controls associated with partial attainment of the current 8-hour Ozone and $PM_{2.5}$ NAAQS and the current PM_{10} NAAQS is the primary input to the cost analysis. The 2010 baseline air quality is a proxy for baseline air quality in the 2015 analysis year. Chapter 4 explains the bases of, and assumptions pertaining to, the 2010 emissions and air quality projections. The cost and emission reductions associated with each illustrative RH progress goal are estimated from a "layered" control baseline that incorporates the 2010 baseline air quality *plus* partial attainment of the current PM_{10} NAAQS *plus* the current ozone NAAQS *plus* partial attainment of the current PM_{10} NAAQS. From this baseline, the four illustrative RH progress goals (two for absolute improvement and two for relative improvement) described in Chapter 3 are analyzed. These goals are: 1.0 dv/15 years, 1.0 dv/10 years, 5% dv/10 years, and 10% dv/10 years.

Figure 6-1 shows the analysis steps that make up these baselines for projecting impacts to 2015.

Figure 6-1
Regional Haze Analysis Baselines through 2015

<u>Regional Haze Analysis Baseline</u>

2010 CAA Baseline ------------> Attain Current PM_{10} NAAQS ------------> Attain Current Ozone and $PM_{2.5}$ NAAQS (includes modest Tier II version mentioned in Chapter 5)

For achieving these illustrative RH progress goals under both emission control Cases A (with fugitive dust controls) and Case B (without fugitive dust controls), control measure selection is modeled using a broader *regional* approach that is more appropriate for addressing air quality problems caused by trans-boundary pollution transport. The particles in many of the pollutants and chemical species that contribute to visibility impairment (particularly $PM_{2.5}$) can be transported over long distances by prevailing winds. Since sources outside of Class I area counties projected not to meet an illustrative RH progress goal may significantly contribute to visibility impairment in those counties, controls may be imposed on sources outside the boundaries of Class I area counties projected to be unable to meet an illustrative progress goal. Given the long-range transport of pollutants and chemical species that contribute to visibility impairment, air quality changes will be realized in Class I area counties that meet the illustrative progress and in counties outside nonattainment counties, some of which initially meet the illustrative progress goals. Ultimately, state and local air pollution control authorities, in cooperation with federal efforts, will devise implementation strategies that achieve visibility improvement goals in a manner that minimizes negative impacts.

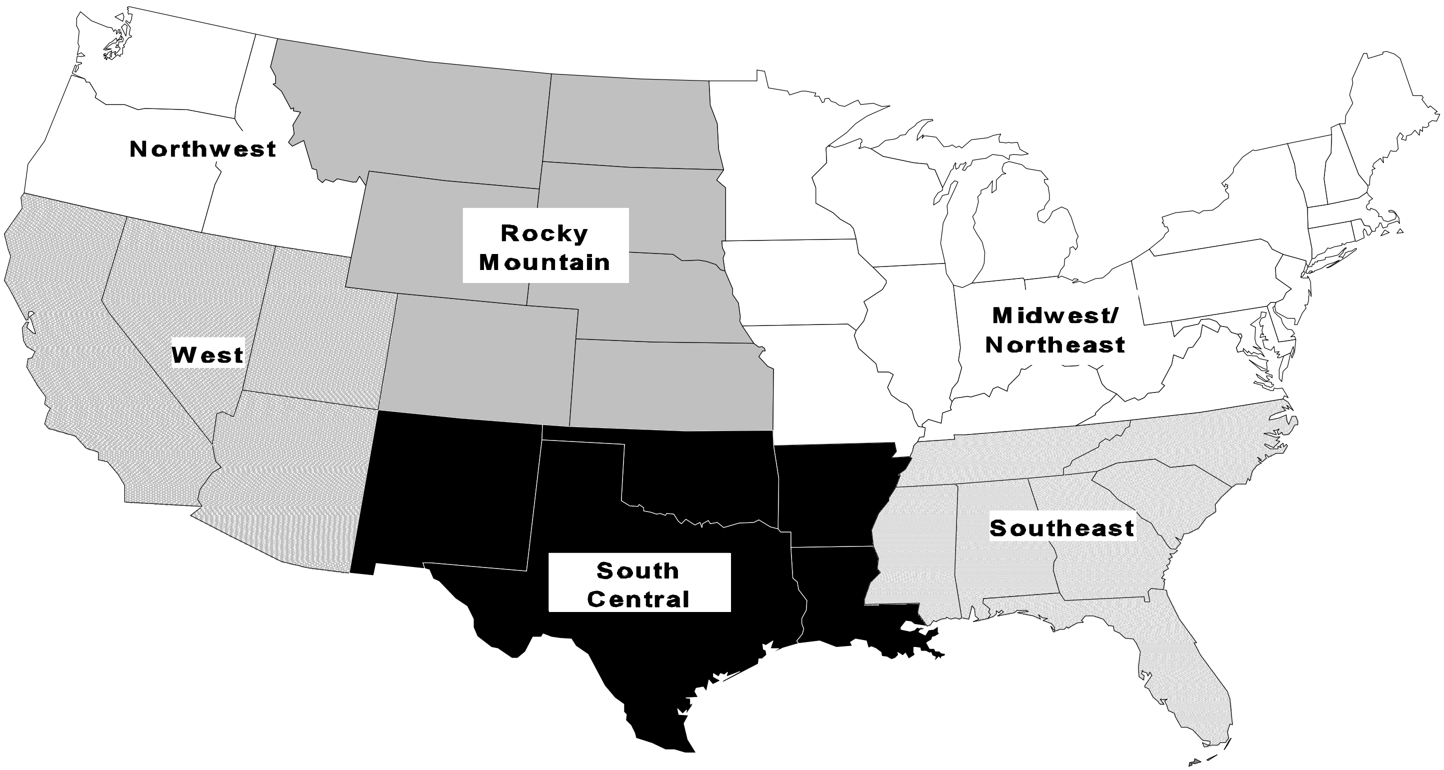
As discussed in Chapter 4, the modeled PM concentrations that are inputs to the cost optimization model are normalized based on factors from ambient concentrations for 711 counties in the contiguous U.S. where monitoring data meets the Agency PM data completeness criteria. These 711 counties are divided into Tiers 1, 2, and 3, with Tier 1 counties (504 out of the 711) having the most complete PM monitoring data.

The analysis is confined to analyzing visibility improvements in the 147 Class I areas located in 121 counties in the 48 contiguous States[1]. Further, the set of Class I areas is subdivided into six control regions. The boundaries of these six control regions are depicted in this chapter in Figure 6-2. The boundaries of these regions are delineated to reflect both the meteorological conditions that influence the long-range transport of visibility precursors and the locations of their major sources (e.g., electric utilities). Control measure selection is limited to emission sources in each control region. In addition, selection of some control measures that primarily affect coarse particles (i.e., particles greater than 2.5 microns) is limited to the county containing the Class I area. This limitation prevents control measures that have a minor effect on visibility (e.g., fugitive dust control for unpaved roads) from being selected in counties that are relatively distant from Class I areas. This limitation is pertinent for understanding the results based on Case A (the emissions control case with fugitive dust controls), but not from Case B (the emissions control case without fugitive dust controls).

1 There are 156 Class I areas in the United States, with 9 Class I areas in Alaska and Hawaii. These States are not included in the modeling for the analyses that are in this RIA.

Figure 6-2

Control Regions in RH Optimization Model



6.3.1 Selecting Control Measures Using the RH Optimization Model

The allocation of SO_2 control responsibility and the control measures selected for sources in the utility sector are analyzed using outputs from the Integrated Planning Model (IPM) (U.S. EPA, 1996). Control measures for all other emissions sectors are selected using the RH optimization model. The types of control measures available to both utility and non-utility sources is discussed in Chapter 5 of this RIA.

The RH optimization model works in a manner similar to the PM optimization model discussed in Chapter 6 of the 1997 RIA. However, in this case, the receptor county of interest contains a Class I area, and reductions in $PM_{2.5}$ precursors at the receptor are translated into improvements in visibility (i.e., reductions in light extinction).

The remainder of this section describes the optimization model used for selecting non-utility control measures in each of the RH modeling regions, and also how changes in visibility are estimated. The optimization model uses several inputs to determine which control measures to apply to meet the illustrative RH visibility progress goals. These inputs are the: 1) Incremental Control Measure Data File, 2) Source-Receptor (S-R) Matrix, and 3) Receptor Input File. Each of these inputs will be described below, after which the optimization procedure will be discussed.

6.3.2 Incremental Control Measure Data File

This file contains the incremental precursor pollutant emission reductions and the total annual cost (in 1990 dollars) for each individual control measure-emission source combination. Each of the emission sources is given a “source number” that is indexed to the S-R matrix (described below). The NOx control measure data have been revised since the RIA for the proposed RH target program was published in order to include control measure cost and efficiency data developed for the final NOx State Implementation Plan (SIP) call RIA. Chapter 5 presents and discusses the control measures used in this analysis.

It should be noted that the costs estimated in this report reflect *real, before-tax, 1990 dollars* and a *7 percent real interest (discount) rate.* "Real" dollars are those uninfluenced by inflation; in other words, a "1990 dollar" is assumed to be worth the same today as it was in 1990. "Before-tax" means that the cost analysis does not consider the effects of income taxes (State or federal). Because income taxes are merely transfer payments from one sector of society to another, their inclusion in the cost analysis would not affect total cost estimates. The year 1990 was selected as the cost reference date to be consistent with the base year for the cost analysis in this report. 1990 is also the base year found in the cost analyses in the 1997 PM and Ozone NAAQS and proposed RH target program RIA and the final NOx SIP call RIA. Finally, to be consistent with the real-dollar analytical basis, a 7 percent real interest rate was used, in accordance with Office of Management and Budget guidance.[1]

The incremental control measure data file is created via optimization on *average annual incremental cost per ton.* For purposes of this analysis, average incremental cost per ton is defined as the *difference* in the annual cost of a control measure and the annual cost of the baseline control (if any), divided by the *difference* in the annual mass of pollutant emissions removed by the control measure and the emissions removed by the baseline control.

The average annual incremental cost per ton is calculated at the source or unit level for point source control measures and at the county level for area and mobile source control measures. For any individual source (e.g., boiler), only the control measures that are most cost-effective at reducing emissions that contribute to visibility impairment are included in the incremental control measure data base. This step eliminates inefficient solutions.

Consider, for example, a furnace that emits 1000 tons per year of primary $PM_{2.5}$. Suppose that this source could be controlled by one of three control devices: 1) fuel gas desulfurization (FGD) scrubber; 2) fabric filter; or 3) electrostatic precipitator (ESP). Further suppose that the associated annual costs, emission reductions, and the average annual incremental cost per ton for these devices is shown in Table 6-1.

Table 6-1
Hypothetical Furnace Control Measures

Control Device	Annual Cost ($/year)	$PM_{2.5}$ Emission Reduction (tons/year)	Average Annual Incremental Cost per Ton ($/ton)
Scrubber	700,000	950	740
Electrostatic Precipitator	600,000	970	620
Fabric filter	800,000	990	810

In this illustration, the ESP is superior to a scrubber from a cost-effectiveness perspective at $620 per ton, as it provides the more emission reduction at a lower annual cost. Because the scrubber provides the lowest emission reduction at a cost greater than that of the ESP, it would never be selected. The fabric filter provides the highest emission reduction (990 tons per year), but its

1 It should be noted that the analyses in this RIA, including the control cost analysis, is a "snapshot" analysis in which results are estimated for a future year (2015). In the case of an analysis in which streams of benefits and costs are brought back to a single net present value, the Agency employs a social discount rate. The discount rate used in this RIA is not the social discount rate. That rate is likely to be well below 7 percent.

annual cost is also the highest of the three options. Because it provides a higher emission reduction than the ESP, even at a higher cost, the fabric filter would be retained in the control measure data base.

6.3.3 Source-Receptor Matrix

The S-R matrix discussed in Chapter 4 provides a link between emission reductions and resulting air quality concentrations. When a control measure from the incremental control measure data file is applied at a source, concentrations for pollutant emissions may be reduced by some amount at *all* associated receptors (i.e., counties) across the multi-state control region.

The S-R matrix was developed from an air quality model that divides sources into two general categories: *elevated point sources* and *area/mobile sources*. In turn, the elevated point sources are aggregated into three categories: 1) sources with effective stack (release) heights less than 250 meters; 2) sources with heights between 250 and 500 meters; and 3) sources with heights above 500 meters. Except for the last category, all sources are assumed to be situated at the population centroid of the county in which they are located. The >500 meter sources are sited according to their individual longitude/latitude coordinates.

The S-R coefficients for a given source and all receptors determine the concentration reductions that occur in proportion to the emission reductions provided by a given control measure. The RH optimization model calculates the light extinction at each Class I area county centroid. If any Class I area county is predicted to fall short of the illustrative progress goal, the optimization model, the control measure selection process is repeated until all Class I area counties meet the illustrative progress goals or a minimum cost per deciview reduced threshold is exceeded by all remaining measures.

Control selection is based on the *cost per average deciview (dv) reduction* rather than average cost per microgram per cubic meter used in the PM NAAQS optimization model. Controls are selected until the modeled dv reduction is achieved in all Class I area counties (in the control region) or until a cost per average deciview of $1 billion is exceeded by all remaining measures. This threshold prevents control measures a great distance from counties not meeting an illustrative progress goal and have little influence on concentrations and visibility in the receptor counties from being applied.

For example, the order of selection on an average incremental cost per ton or average incremental cost per deciview basis for controlling Volatile Organic Compounds (VOC) emissions in a hypothetical county may be: 1) pressure/vacuum vents and vapor balancing for Stage I service station refueling, 2) VOC incineration for metal can coating operations, and 3) VOC content limits and improved transfer efficiency for autobody refinishing operations. However, each of these individual measures has the same S-R coefficient and source number, because all area sources in a county are assumed to release their emissions at the same height and location (the county centroid). Consequently, the cost per microgram per cubic meter reduced, which, within a given aggregation of sources, is directly proportional to the cost per ton reduced, will follow the same order of selection as the *average incremental cost per deciview reduced* of precursor reduced. Table 6-2 provides an indication of the magnitude of the S-R coefficients for a hypothetical receptor (Acme County).

Table 6-2
Simple Illustration of S-R Coefficients For
The Hypothetical Acme County Receptor

Source (all in the county)	Primary $PM_{2.5}$ Coefficient	Nitrate Coefficient	Sulfate Coefficient	Ammonia (NH_3) Coefficient
Point (0-250m)	0.154×10^{-7}	0.191×10^{-8}	0.392×10^{-9}	0.147×10^{-7}
Point (250-500m)	0.258×10^{-8}	0.243×10^{-9}	0.518×10^{-10}	0.277×10^{-8}
Area Sources	0.224×10^{-7}	0.267×10^{-8}	0.546×10^{-9}	0.215×10^{-7}

The units of the coefficients are *seconds per cubic meter*. The S-R matrix coefficients generally decrease with distance, dropping off rapidly beyond a one or two county layer from the receptor county. To illustrate how these coefficients are used to calculate changes in air quality, consider a 1,000 ton per year reduction in primary $PM_{2.5}$ emissions from area sources in Acme County. The change in $PM_{2.5}$ concentration is calculated as follows:

Reduction = (1,000 tons/year)(0.224×10^{-7} sec/m^3)(28,767 micrograms-yr/ton-sec)
= 0.644 micrograms per cubic meter,
where 28,767 is the micrograms-yr/ton-sec conversion factor.

6.3.4 Receptor Input File

This file contains the starting total county-level normalized PM_{10} and $PM_{2.5}$ concentrations for the 2010 CAA baseline emissions and partial attainment Ozone and $PM_{2.5}$ NAAQS scenarios. The normalization procedure used to calibrate predicted concentrations to actual monitor data is described in Chapter 4.

6.3.5 Number of Monitored Counties

This analysis selects control measures for meeting RH illustrative progress goals based on a set of $PM_{2.5}$ monitoring data from a subset of counties currently monitored for PM_{10}. There are 711 counties that currently contain monitors capable of measuring PM_{10} air quality; however, only 504 of these monitors meet what is referred to in this analysis as *Tier 1* criteria. Chapter 4 provides a more detailed discussion of the monitoring criteria used to establish tiers.

6.3.6 Scaling Annual Average Deciview Values Relative to Average Peak Values

The illustrative RH progress goals analyzed in this RIA are meant to examine a deciview (or absolute) change or a percentage (relative) change in the average deciview value of the 20 percent worst days over a 10-year period. However, the S-R matrix used to estimate pollution concentrations that contribute to RH formation, outputs annual average values for the pollutants of concern (ammonium sulfate, ammonium nitrate, organic and elemental carbon, and primary PM_{10} and $PM_{2.5}$). This analysis uses the most recent monitoring data from Class I areas to translate a deciview change or a percentage deciview change in the 20 percent worst days to an equivalent change for an annual average day. Appendix C contains the data used to make this calculation.

The average of the 20 percent worst days each year is also be referred to as the 90th percentile value, and can be compared to the annual average or mean value. The ratio of the 90th percentile deciview value to the mean deciview value varies by Class I area. Based on the most recent Interagency Monitoring for Protection of Visual Environments (IMPROVE) data, the average ratio of the 90th percentile deciview value to the mean deciview value for all Class I areas is 1.4. Therefore, a 1.0 deciview change in the 20 percent worst days correlates to a 0.7 deciview change in the annual average day (1.0 divided by 1.4). Similarly, a 0.67 deciview change in the 20 percent worst days correlates to a 0.5 deciview change in the annual average day (0.67 divided by 1.4). These annual average equivalent values are used in this analysis. For the relative progress goal, the same adjustment occurs. A 10 percent deciview change in the 20 percent worst days correlates to a 7 percent deciview change in the annual average day (10 divided by 1.4). Finally, a 5 percent deciview change in the 20 percent worst day days correlates to a 3.5 percent deciview change in the annual average day (5 divided by 1.4).

6.3.7 Estimating Visibility

Decreases in visibility are often directly proportional to decreases in light transmittance in the atmosphere (Trijonis et al., 1990). Light transmittance is attenuated by scattering and absorption by both gases and particles. The light-extinction coefficient is a measure of the total fraction of light that is attenuated per unit distance (Sisler, 1996):

$$b_{ext} = b_{Ray} + b_{sp} + b_{ag} + b_{abs}$$

where:

b_{ext}	=	total light extinction coefficient (1/Mm),
b_{Ray}	=	light extinction coefficient due to natural Rayleigh scatter (1/Mm),
b_{sp}	=	light extinction coefficient due to scattering by particles (1/Mm),
b_{ag}	=	light extinction coefficient due to absorption by gases (1/Mm), and
b_{abs}	=	light extinction coefficient due to absorption by particles (1/Mm).

The light extinction coefficient is calculated by multiplying the concentration of an aerosol species by its light-extinction efficiency, and summing over all species.

The term b_{Ray} refers to the natural Rayleigh scatter from air molecules, mainly nitrogen and oxygen. Depending on altitude, this term has a value of 9 to 12 Mm^{-1} (inverse megameters) (Sisler and Malm, 1994).

The term b_{sp} can be broken into the various species of fine and coarse particles that scatter light. Because fine particles are much more efficient at light scattering than coarse particles, several fine particle species are specified, whereas coarse particles are kept as one category. Fine particles with significant light-extinction efficiencies include sulfates, nitrates, organic carbon, elemental carbon (soot), and soil (Sisler, 1996).

A complicating factor for sulfates, nitrates, and some organic compounds is that these aerosols are hygroscopic, i.e., they absorb water, which greatly enhances their light-scattering abilities. The amount of water absorbed is a function of the relative humidity. A relationship between the relative humidity and scattering efficiency for ammonium sulfate aerosols has been developed, and is also applied to ammonium nitrate aerosols (Sisler, 1996). Recent research indicates that organics are not hygroscopic to weakly hygroscopic (Sisler, 1996) and thus in this analysis, the light scattering efficiency for organics is not assumed to be a function of the relative humidity.

A detailed expression for b_{sp} can thus be written (Sisler, 1996):

$$b_{sp} = 3f(RH) \cdot [SULFATE] + 3f(RH) \cdot [NITRATE] + 4[OMC] + 1[SOIL] + 0.6[CM]$$

where:

3	=	dry scattering efficiency of sulfate and nitrates (m^2/g),
f(RH)	=	function describing scattering characteristics of sulfates and nitrates, based on the relative humidity (unitless),
[*SULFATE*]	=	concentration of ammonium sulfate aerosols ($\mu g/m^3$),
[*NITRATE*]	=	concentration of ammonium nitrate aerosols ($\mu g/m^3$),
4	=	dry scattering efficiency of organic mass from carbon (m^2/g),
[*OMC*]	=	concentration of organic aerosols ($\mu g/m^3$),
1	=	dry scattering efficiency of soil (m^2/g),
[*SOIL*]	=	concentration of fine soil ($\mu g/m^3$),
0.6	=	dry scattering efficiency of coarse particles (m^2/g), and
[*CM*]	=	concentration of coarse particles ($\mu g/m^3$).

The function *f(RH)* is calculated as follows:

$$f(RH) = t_0 + t_2(1/(1-RH))^2 + t_3(1/(1-RH))^3 + t_4(1/(1-RH))^4$$

where:

RH	=	relative humidity, and
t_x	=	parameters presented in Table 6-3 below.

Table 6-3
Parameter Determining the Effect of Relative Humidity on Visibility

Season	t_0	t_2	t_3	t_4
Spring	0.7554	0.3091	-0.0045	-0.0035
Summer	0.5108	0.4657	-0.0811	0.0043
Autumn	-0.0269	0.8284	-0.1955	0.0141
Winter	1.1886	0.2869	-0.0332	0.0011
Annual	0.5176	0.5259	-0.0947	0.0056

Source: Table 5.1, Sisler, 1996.

The term b_{ag} represents absorption due to gases; NO_2 is the only major light-absorbing gas in the lower atmosphere. This component is assumed to be negligible since concentrations of NO_2 are expected to be negligible in rural areas (Sisler and Malm, 1994), which is generally applicable for Class I areas. However, this may be a poor assumption for locations close to significant NO_x emission sources, such as power plants or urban areas (Sisler, 1996). Under those conditions, the visibility improvement due to reductions in NO_2 could be understated.

The final term of the light-extinction coefficient equation, b_{abs}, represents absorption of light by elemental carbon (EC). Recent research has indicated that direct measurements of absorption by the laser integrated plate method (LIPM) are much more accurate than using absorption estimates based on mass concentrations of light-absorbing carbon. For that reason, this analysis bases b_{abs} on empirical data from monitored sites in the IMPROVE network.

Once the light-extinction coefficient is determined, the visibility index called deciview (*dv*) can be calculated (Sisler, 1996):

$$dv = 10 \cdot \ln(b_{ext} \cdot 10^{-3} / 0.01\, km^{-1})$$

where:

10^{-3} = constant to convert Mm^{-1} to km^{-1}.

A change of one *dv* represents a change of approximately 10 percent in b_{ext}, "which is a small but perceptible scenic change under many circumstances" (Sisler, 1996, p.1-7).

6.3.8 Estimating the Effect of Control Measures on Visibility

Given the available data available from the IMPROVE monitoring network and the changes in sulfate, nitrate, elemental carbon, organic carbon, and primary PM emissions modeled using the S-R matrix described earlier in this chapter and in Chapter 4, light extinction (b_{ext}) is calculated using the following equation:

$$\begin{aligned} b_{ext} = {} & b_{Ray} + 3f(RH) \cdot [SULFATE] + 3f(RH) \cdot [NITRATE] + \\ & 4[OMC] + 1[SOIL] + 0.6[CM] + b_{abs} \end{aligned}$$

The S-R matrix provides concentration estimates of ammonium sulfate (SULFATE), ammonium nitrate (NITRATE), organic and elemental carbon (OMC), fine particle soil (SOIL), and coarse mass (CM= PM_{10} - $PM_{2.5}$). A common assumption for light scattering by background gases (b_{Ray}) is 10 Mm^{-1}. Appendix C provides estimates for f(RH), OMC, SOIL, and b_{abs} based on summary data from 43 relevant IMPROVE monitoring sites between 1992-1995. For Class I areas without monitoring data, values are assigned based on either the closest monitored site or an average of up to three proximate monitored sites. The values are assumed constant in this analysis, even though it is known that certain types of control measures may affect the baseline levels of OMC and b_{abs}. The exact relationship between these factors and specific control measures has not been established, and therefore, these values are held constant. These values then serve as inputs to the RH optimization model.

6.3.9 RH Optimization Model Routine

The optimization routine developed for this analysis employs the following steps:

Step 1. The remaining control measures in the incremental control measure data file are sorted by source number, precursor pollutant controlled, and cost per ton of pollutant reduced.

Step 2. The *incremental* improvement in visibility is calculated *for each Class I area county* for the least costly (on a cost per ton basis) control measure for each individual source/pollutant combination.

Step 3. The measure with the *lowest average cost per increment of visibility improvement* is selected and the deciview levels at each receptor are adjusted to reflect implementation of the selected measure.

Step 4. Steps 2 through 3 are repeated until all input receptors meet the target level *or* all remaining measures are exhausted. A $1 billion per microgram per cubic meter control measure selection threshold (translated into a cost per average deciview threshold) is used in the RH optimization model. The annual cost threshold of $1 billion per microgram per cubic meter is the one used in the PM optimization model.

Step 5. Adjust final post-control visibility predictions in all Class I areas nationwide to account for the trans-boundary effect of control measures selected outside each control region.

Figure 6-3 provides a flowchart for the RH optimization routine.

To illustrate steps 3 and 4, consider the example shown in Table 6-4. This table lists three control measures (A, B, and C) and four receptors (counties 1, 2, 3, and 4). The annual cost (in millions of 1990 dollars per year) is given for each control measure. Also listed for each measure is the deciview improvement at each receptor that result if that measure is applied. For control measure A, these improvements range from 0.1 to 0.3 dv, and average 0.23 dv (column 2). Listed below these reductions are the cost-per-microgram-per-cubic meter ratios for each of the four receptors. These ratios are obtained by dividing the annual cost for control measure A by each of the four $PM_{2.5}$ reductions. The last number in column 2 is the ratio of the annual cost for control measure A divided by the average microgram per cubic meter $PM_{2.5}$ reduction among the four receptors. Similar calculations are made for control measures B and C, in turn.

Table 6-4
Simple Illustration of the Calculation of Cost per Average Deciview Reduced

		Control Measure A	Control Measure B	Control Measure C
Cost (million $/yr)		1.0	1.5	1.5
Deciview reduced (dv)				
	Receptor 1	0.20	0.30	0.80
	Receptor 2	0.30	0.40	0.10
	Receptor 3	0.10	0.50	0.10
	Receptor 4	0.30	0.40	0.25
	Average	0.23	0.40	0.25
Cost per deciview reduced				
	Receptor 1	5.0	5.0	1.9

Receptor 2	3.3	3.8	15.0
Receptor 3	10.0	3.0	15.0
Receptor 4	3.3	3.8	--
Average	4.4	3.8	6.0

The control measure selected in this optimization scheme is the one that gives the lowest cost per average deciview reduced. Based on this decision criterion, control measure B is selected first, followed by measure A and measure C, as needed. But suppose, for instance, that the application of measure B brought receptors 2 through 4 into compliance with the illustrative RH progress goal of interest. If that is the case, the next iteration of the optimization model results in the selection of measure C, in preference to measure A. Why? Since control measure B brought receptors 2 through 4 into compliance, they are no longer included in the calculation of the cost per average deciview reduced. This leaves only receptor 1 under consideration. And, as Table 6-4 shows, control measure C has the lowest annual cost per average deciview reduction ratio for receptor 1. (Note: Because there is only one receptor, this ratio also equals the lowest annual cost per average microgram per cubic meter). Consequently, measure C is selected.

Because the optimization model only includes receptors out of compliance in the calculation of the cost per average microgram reduced, selection of measures that have little or no impact in reducing concentrations in non-complying areas is avoided. Finally, the reader should keep in mind that the scope of this example has been kept small for purposes of illustration. During each iteration of the RH optimization model, the control measure selections are made from literally thousands of measure-receptor combinations.

6.3.10 Baseline Visibility

The visibility baseline in this analysis is represented by the estimated visibility improvement between the benchmark case and the partial attainment of Ozone and $PM_{2.5}$ NAAQS case (which includes a modest version of the Tier II program described in Chapter 5). Table 6-5 summarizes the visibility measurements in terms of deciviews for the two cases. As the table shows, the average visibility improvement in the annual average deciview value for counties containing Class I areas in the Midwest/Northeast and the Southeast control regions is more than the illustrative progress goal of 1.0 dv/10 years. Given the 1.4 to 1 ratio of the deciview measurement for the 20 percent worst days to the case of annual average deciview change (as mentioned in Chapter 4), the visibility improvement is much more pronounced on the worst days, the time of year in which the greatest visibility progress is sought given the form of the illustrative goals described in Chapter 3.

Table 6-5
Projected Annual Average Deciview Values by Control Region[a]

Region	No. of Counties Containing Class I Areas	2010 CAA Baseline (Benchmark)	Partial Attainment of Ozone and $PM_{2.5}$ NAAQS including a version of the Tier II program	Average Annual Deciview Improvement in Baseline for RH Progress Goals
Midwest/Northeast	16	23.1	21.1	2.0
Southeast	13	22.5	21.0	1.5
South Central	14	16.8	16.3	0.5
Rocky Mountain	30	17.6	17.1	0.5
Northwest	18	19.3	19.1	0.2
West	30	17.8	17.1	0.7
Nation	121	19.1	18.3	0.8

[a] The regulatory baseline for analysis of these illustrative RH progress goals is the 2010 CAA benchmark *plus* partial attainment of the 8-hour Ozone and $PM_{2.5}$ NAAQS. This baseline includes a modest version of theTier II program described in Chapter 5 of this RIA.

Table 6-6 indicates the number of Class I area counties for which additional control measures may be needed incremental to the baseline (i.e., incremental to partial attainment of the $PM_{2.5}$ 15/65 standard and the 8-hour Ozone standard). There are substantial visibility improvements due to partial attainment of the $PM_{2.5}$ and Ozone NAAQS that includes a modest version of the Tier II program described in Chapter 5. Specifically,

! Nearly all Class I area counties in the Midwest/Northeast and Southeast regions are projected to meet the illustrative RH progress goals without any additional controls beyond partial attainment of the $PM_{2.5}$ 15/65 standard and the 8-hour Ozone standard.

! There is substantial visibility improvements in the South Central, Rocky Mountain, andwest control regions under all the illustrative progress goals except the 10% dv/10 year. There is a substantial reduction in annual average shortfall for Class I area counties in these control regions resulting from application of baseline control measures.

! The Northwest control region is expected to have the least visibility improvement under any of these illustrative progress goals. This is to be expected since most of the projected nonattainment with the $PM_{2.5}$ and Ozone NAAQS occurs in the Midwest/Northeast, Southeast, and other control regions so that is where the controls are applied. Since the Northwest is installing fewer controls to meet the NAAQS, less progress towards the illustrative RH progress goals would be expected.

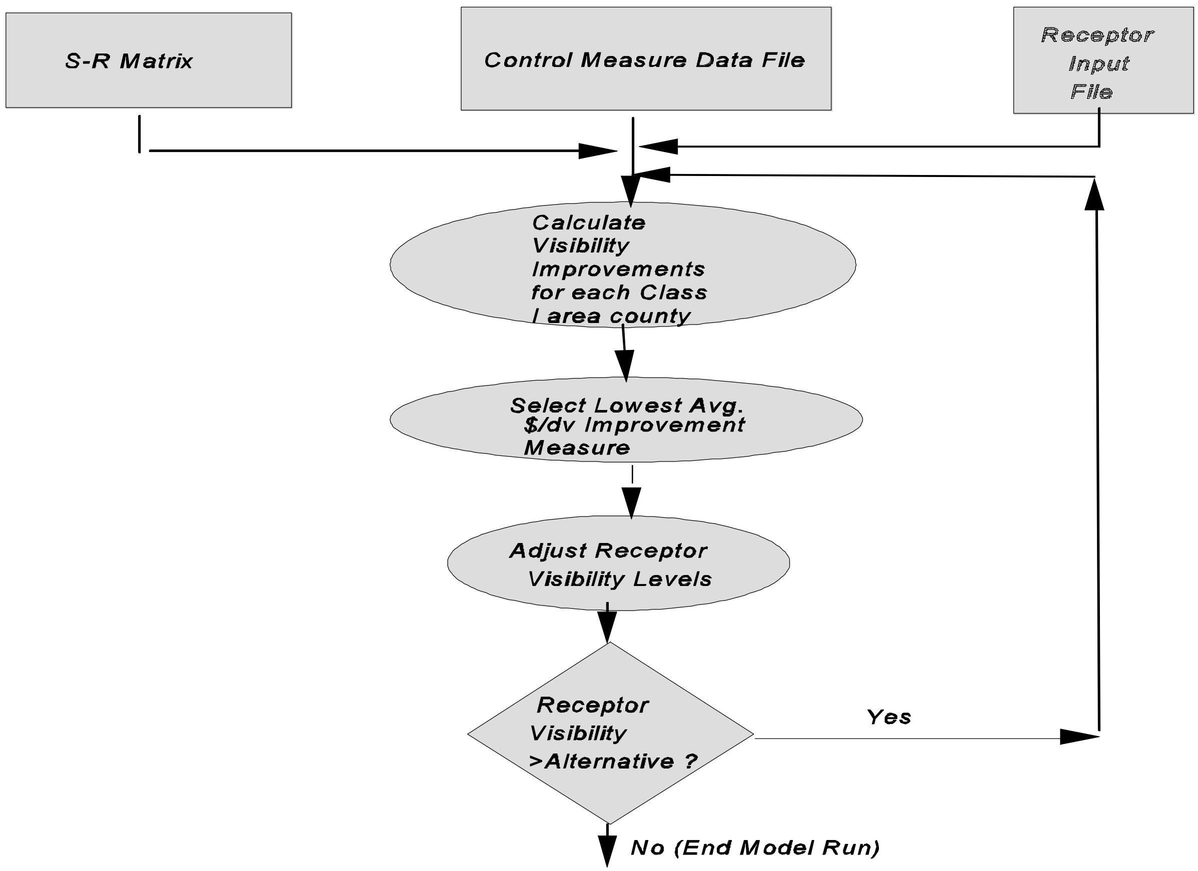
It should also be noted that the control regions in thewest are have the highest proportion of predicted biogenic aerosol emissions, which places them closer to natural conditions than other regions. This would tend to support establishing differing RH progress goals for these areas.

Table 6-6
Number of Class I Area Counties Not Meeting RH Illustrative Progress Goals in the Baseline[a]

Control Region	Number of Class I Area Counties	Number of Class I Area Counties After $PM_{2.5}$ and 8-hour O_3 NAAQS Control			
		1.0 Deciview Goal Over 15 Years (0.67 Deciview Goal)	1.0 Deciview Goal Over 10 Years (1.0 Deciview Goal)	5% Deciview Goal Over 10 Years	10% Deciview Goal Over 10 Years
Midwest/Northeast	16	0	0	0	1
Southeast	13	0	1	1	7
South Central	14	11	11	11	14
Rocky Mountain	30	14	27	26	30
Northwest	18	17	18	18	18
West	30	16	19	18	24
Nation	121	58	76	74	94

[a] The baseline for the RH rule is the partial attainment control case for the $PM_{2.5}$ and Ozone NAAQS presented in the 1997 RIA.

FIGURE 6-3
RH OPTIMIZATION MODEL STEPS



6.4 Emission Reduction and Air Quality Impacts

This section presents the emission reduction and air quality impact results for the analysis of the illustrative RH progress goals under the emission control Cases A and B. The results presented in this section are incremental to partial attainment of the Ozone and $PM_{2.5}$ NAAQS, which is the baseline for these analyses. Consequently, there are few projected emission reductions from certain control regions, such as the Midwest/Northeast and Southeast, since virtually all Class I area counties in these regions are expected to meet the illustrative progress goals in the baseline. This section includes estimates of the emission reductions and visibility improvements resulting from control measures selected in each control region, and estimates of the change in the status of Class I area counties in meeting the illustrative progress goals for the counties initially projected not to meet the RH progress goals.

Table 6-7 presents the emission reductions, by control region and nationally, associated with the illustrative RH progress goals for the year 2015 for Case A. The emission reductions do not account for potential increases in emissions due to the small additional energy requirements for producing, installing, and operating selected control devices. These reductions also do not reflect the visibility improvement from reduction of NO_2 emissions.

Table 6-7
Emission Reductions by Control Region and Nationally
for Illustrative RH Progress Goals in the Year 2015 for Case A[a] (Tons reduced)[b]

RH Progress Goal	Control Region	NOx	SO_2	$PM_{2.5}$	PM_{10}	VOC	SOA	OC	EC
1.0 deciview/15 year	Midwest/Northeast	0	0	0	0	0	0	0	0
	Southeast	0	1	60	60	50	1	20	2
	South Central	101,500	290	12,800	180,700	19,400	300	3,000	600
	Rocky Mountain	84,300	100	6,700	88,000	9,300	100	1,300	200
	Northwest	24,200	1,500	41,200	68,700	43,800	1,500	17,600	3,500
	West	80,100	10	4,100	60,400	800	10	500	100
	Total	**290,100**	**1,900**	**64,860**	**397,800**	**73,350**	**1,910**	**22,420**	**4,400**
1.0 deciview/10 year	Midwest/Northeast	0	0	300	3,300	0	0	10	3
	Southeast	900	6,700	3,200	11,600	7,600	200	1,500	200
	South Central	106,000	41,700	12,900	181,000	21,000	300	3,000	600
	Rocky Mountain	142,000	56,800	12,500	165,800	13,000	100	3,100	400
	Northwest	47,400	14,300	58,400	124,000	72,000	1,700	24,100	4,100
	West	81,600	4,400	5,600	74,500	1,000	10	1,000	200
	Total	**377,900**	**123,900**	**92,900**	**560,200**	**114,600**	**2,300**	**32,700**	**5,500**
5 Percent/10 year	Midwest/Northeast	0	0	200	1,300	0	0	2	2
	Southeast	10	0	800	5,300	3,500	100	300	100
	South Central	105,300	41,200	12,800	180,800	19,500	300	3,000	600
	Rocky Mountain	141,400	41,000	8,100	91,900	12,900	100	1,900	300
	Northwest	74,300	17,300	50,800	94,400	95,300	1,900	20,800	3,900
	West	80,800	4,800	6,200	71,000	900	8	1,300	200
	Total	**401,800**	**104,300**	**78,900**	**444,700**	**132,100**	**2,400**	**27,300**	**5,100**

Table 6-7
Emission Reductions by Control Region and Nationally for Illustrative RH Progress Goals in the Year 2015 for Case A[a] (Tons reduced)[b]
(Continued)

RH Progress Goal	Control Region	NOx	SO_2	$PM_{2.5}$	PM_{10}	VOC	SOA	OC	EC
10 Percent/10-year	Midwest/ Northeast	33,100	130,900	6,200	37,900	29,200	200	400	100
	Southeast	10,800	107,300	80,700	169,500	26,400	700	22,200	3,200
	South Central	135,000	149,900	22,800	214,000	39,100	500	5,000	1,000
	Rocky Mountain	219,700	80,500	13,400	178,800	13,800	100	3,300	400
	Northwest	117,800	46,300	90,400	195,600	107,300	2,000	35,900	5,300
	West	85,400	7,400	8,900	84,700	4,300	100	1,800	300
	Total	**601,800**	**522,300**	**222,400**	**880,500**	**220,100**	**3,600**	**68,600**	**10,300**

[a] Case A represents a control case in which additional control measures beyond baseline are applied including fugitive dust control measures.
[b]Totals may not agree due to rounding.

To provide some perspective on the estimated emissions reductions needed to meet these illustrative progress goals, some substantial emission reductions are projected to occur under Case A for most of the pollutants controlled as shown in Table 6-7. Some substantial emission reductions compared to emission reductions within the National Particulate Inventory (NPI) are projected to occur under Case A for most of the pollutants controlled under the control measures applied. These reductions are roughly 2 to 6 percent based on the most stringent illustrative progress goal (10% dv/10 years) of what is projected under the benchmark case for most of these pollutants (U.S. Environmental Protection Agency, 1997a). For $PM_{2.5}$, the projected emissions reductions under Case A are greater than those for the benchmark case, but less than the emissions reductions projected under the partial attainment of the $PM_{2.5}$ and Ozone NAAQS (up to roughly 50 percent of reductions projected under partial attainment of these NAAQS, based on comparison with the most stringent progress goal). For PM_{10}, the projected emission reductions are as much as 35 percent compared to those in the benchmark case, but only 18 percent of the emission reductions projected in the baseline under partial attainment of the $PM_{2.5}$ and Ozone NAAQS (again, based on comparison to the most stringent progress goal). In addition, these reductions are generally less than 50 percent of the emission reductions obtained in the baseline due to partial attainment of the Ozone and $PM_{2.5}$ NAAQS and PM_{10} NAAQS, except for nitrogen oxides (NOx) emissions. The reductions in NOx emissions under Case A are roughly up to 75 percent of the reductions predicted in the partial attainment case for the Ozone and $PM_{2.5}$

NAAQS and PM_{10} NAAQS (U.S. Environmental Protection Agency, 1999a) based on comparison with the most stringent progress goal. The lack of emission reductions shown for the Midwest/Northeast and Southeast modeling regions under Case A for most of the illustrative progress goals is due to Class I area counties meeting these goals in the baseline.

Emissions reductions by control region and nationally for these illustrative progress goals are shown in Table 6-8.

Table 6-8
Emission Reductions by Control Region and Nationally
for Illustrative RH Progress Goals in the Year 2015 for Case B[a] (Tons reduced)[b]

RH Progress Goal	Control Region	NOx	SO_2	$PM_{2.5}$	PM_{10}	VOC	SOA	OC	EC
1.0 deciview/15 year	Midwest/Northeast	0	0	200	1,300	0	0	2	2
	Southeast	0	1	60	60	50	1	20	2
	South Central	105,800	41,700	7,200	9,700	20,400	300	2,800	500
	Rocky Mountain	137,500	41,300	4,400	8,000	12,900	100	1,600	200
	Northwest	30,900	8,400	42,600	46,500	50,400	1,600	18,100	3,600
	West	81,600	3,900	3,800	7,100	900	10	1,300	200
	Total	**355,800**	**95,300**	**58,260**	**72,700**	**84,600**	**2,010**	**23,800**	**4,500**
1.0 deciview/10-year	Midwest/Northeast	0	0	200	1,300	0	0	2	3
	Southeast	6,600	70,900	61,100	85,200	21,200	500	14,800	2,400
	South Central	107,500	42,400	7,300	9,900	21,100	300	2,800	500
	Rocky Mountain	202,200	63,200	7,300	11,900	13,900	100	2,900	400
	Northwest	77,900	15,800	83,000	94,000	86,400	1,800	34,800	5,000
	West	83,400	6,200	5,000	8,500	1,500	10	1,500	300
	Total	**477,600**	**198,500**	**163,900**	**210,800**	**144,100**	**2,700**	**56,800**	**8,600**
5 Percent/10-year	Midwest/Northeast	0	0	200	1,300	0	0	2	2
	Southeast	6,600	70,900	61,100	85,200	21,200	500	14,800	2,400
	South Central	104,000	42,400	7,200	9,800	21,000	300	2,800	500
	Rocky Mountain	142,600	56,800	5,000	8,700	12,900	100	1,800	300
	Northwest	87,000	19,000	80,300	90,800	95,000	1,900	33,400	4,900
	West	81,800	4,800	4,000	7,400	1,000	10	1,400	200
	Total	**422,000**	**193,300**	**157,800**	**203,200**	**151,100**	**2,800**	**54,200**	**8,300**

Table 6-8
Emission Reductions by Control Region and Nationally
for Illustrative RH Progress Goals in the Year 2015 for Case B[a] (Tons reduced)[b]

RH Progress Goal	Control Region	NOx	SO_2	$PM_{2.5}$	PM_{10}	VOC	SOA	OC	EC
10 Percent/10-year	Midwest/ Northeast	33,100	137,500	6,400	15,100	30,700	300	900	200
	Southeast	20,700	197,100	123,300	161,600	52,900	1,800	43,400	6,300
	South Central	134,900	149,900	16,500	23,400	39,000	500	5,100	1,000
	Rocky Mountain	220,200	80,500	7,700	12,500	14,500	100	3,000	400
	Northwest	118,100	46,500	86,500	99,200	108,200	2,000	35,300	5,200
	West	85,600	7,800	5,800	9,900	4,700	100	1,500	300
	Total	**612,600**	**619,300**	**246,200**	**321,700**	**250,000**	**4,800**	**89,200**	**13,400**

[a] Case B represents a control case in which additional control measures beyond baseline are applied with no fugitive dust control measures allowed.
[b]Totals may not agree due to rounding.

To provide some perspective on the estimated emissions reductions needed to meet these illustrative progress goals, some substantial emission reductions compared to reductions within the NPI are projected to occur under Case B for most of the pollutants controlled as shown in Table 6-8. These reductions are roughly 2 to 5 percent based on the most stringent illustrative progress goal (10%/10 years) of the emission reductions projected under the benchmark case (2010 CAA baseline) for most of these pollutants (U.S. Environmental Protection Agency, 1997a). For $PM_{2.5}$, the projected emissions reductions under Case A are greater than those for the benchmark case, but less than the emissions reductions projected under the partial attainment of the $PM_{2.5}$ and Ozone NAAQS which includes a modest version of the Tier II program (up to roughly 45 percent of reductions projected under partial attainment of these NAAQS, based on comparison to the most stringent progress goal). For PM_{10}, the projected emissions reductions under Case A are as much as 13 percent compared to the reductions for the benchmark case, but only 7 percent of the emissions reductions projected under the partial attainment of the $PM_{2.5}$ and Ozone NAAQS which includes a modest version of the Tier II program (again, based on comparison to the most stringent progress goal).

In addition, these reductions are generally less than 30 percent of the emission reductions obtained in the baseline due to partial attainment of the Ozone and $PM_{2.5}$ NAAQS and PM_{10} NAAQS, except for NOx emissions. The reductions in NOx emissions under Case B are roughly up to 77 percent of the reductions predicted in the partial attainment case for the Ozone and $PM_{2.5}$ NAAQS and PM_{10} NAAQS (U.S. Environmental Protection Agency, 1999b) based on comparison to the most stringent progress goal. In addition, the lack of emission reductions shown for the Midwest/Northeast and Southeast modeling regions under Case B for most of the illustrative progress goals is due to Class I area counties meeting these goals in the baseline.

We would expect the amount of environmental progress and mix of emission reductions to change between emissions control Cases A and B. In the analyses presented in this RIA, these expectations are realized. The variation between Case A and Case B reflects the consequence of uncertainties in emission inventories, air quality modeling, and control measure effectiveness.

6.5 Visibility Improvement Results

This section presents the incremental visibility improvements achieved for each illustrative RH progress goal in Class I area counties that did not achieve the goal in the baseline under both emissions control Case A and Case B. Included are estimates of the additional number of Class I area counties that meet the illustrative RH progress goal, as well as the average improvement realized. As discussed in section 6.3.4, a 1.0 deciview improvement goal for the average 20 percent worst days is roughly equivalent to a 0.7 deciview improvement goal for the annual average day. Similarly, a 0.67 deciview improvement in the average 20 percent worst days is roughly equivalent to a 0.5 deciview improvement in the annual average day. In addition, a 5 percent deciview improvement goal for the average 20 percent worst days is roughly equivalent to a 3.5 percent deciview improvement in the annual average day. Finally, a 10 percent deciview improvement goal for the average 20 percent worst days is roughly equivalent to a 7 percent deciview improvement in the annual average day.

Case A

Table 6-9 presents the number of Class I area counties that initially do not achieve each illustrative RH progress goal and the estimated number of Class I area counties that are not able to achieve the goals after additional control measures are modeled under Case A (with fugitive dust controls included).

Table 6-9
Estimated Number of Class I Area Counties That Do NOT Achieve Illustrative Regional Haze Progress Goals and the Average Deciview Shortfall Under Case A[c]

Region	1.0 Deciview Goal Over 15 Years (0.67 Deciview Goal)			1.0 Deciview Goal Over 10 Years (1.0 Deciview Goal)				5 Percent Deciview Goal Over 10 Years			10 Percent Deciview Goal Over 10 Years	
	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall
Midwest/Northeast	0	0	--	0	0	--	0	0	--	1	1	0.01
Southeast	0	0	--	1	0	--	1	1	0.01	7	1	0.47
South Central	11	2	0.15	11	3	0.23	11	2	0.14	14	12	0.31
Rocky Mountain	21	1	0.06	27	4	0.09	26	1	0.04	30	22	0.25
Northwest	18	2	0.07	18	2	0.10	18	2	0.08	18	12	0.22
West	16	7	0.11	18	10	0.24	18	8	0.27	24	20	0.58
Nation	58	12	0.10	75	19	0.19	74	14	0.19	94	68	0.35

aBaseline represents class I area counties that do not achieve sufficient progress toward the illustrative progress goal after considering partial attainment of the $PM_{2.5}$ 15/65 standard and the 8-hour Ozone standard.
bPost-control represents counties that do not achieve sufficient additional progress toward the visibility goal after considering additional controls not already selected in the $PM_{2.5}$ 15/65 analysis. cCase A represents an emissions control case in which additional control measures beyond baseline are applied including fugitive dust control measures.

This table indicates that 12 of the 66 Class I area counties initially unable to meet the 1.0 dv/15 years goal may not meet the goal with application of additional control measures under Case A, and 19 of the 75 counties initially unable to meet the 1.0 dv/10 years goal may not meet this goal with application of additional control measures under Case A. This table also indicates that 14 of the 74 Class I area counties initially unable to meet the 5% dv/10 years goal cannot meet this goal with application of additional control measures under Case A, and 68 of the 94 Class I area counties initially unable to meet the 10% dv/10 years goal cannot meet this goal with application of additional control measures under Case A.

There are a considerable number of Class I area counties nationwide that are expected to meet the illustrative progress goals under Case A. The only exception is for the 10 % dv/10 years goal. The percentage of Class I area counties nationwide that are expected to meet these illustrative progress goals is listed in Table 6-10. As indicated in that table, the percentage of Class I area counties that meet the illustrative progress goals ranges from 22 to 45 percent from benchmark to baseline, and ranges from 43 to 90 percent with the incremental control measures from baseline included. Consequently, there is a substantial amount of progress towards meeting the visibility goals in the benchmark and baseline as well as with application of incremental control measures.

Table 6-10
Percentage of Class I Area Counties That Meet the RH Illustrative Progress Goals in the Benchmark and Beyond Under Case A[a]

	Percentag e of Class I area counties meeting the 1.0 Dv/ 15 Years Progress Goal	**Percentage of Class I area counties meeting the 1.0 Dv/ 10 Years Progress Goal**	**Percentage of Class I area counties meeting the 5 Percent Dv/10 Years Progress Goal**	**Percentage of Class I area counties meeting the 10 Percent Dv/10 Years Progress Goal**
Benchmark to Baseline	52	38	39	22
Baseline to Incremental Control Strategies	38	46	50	21
Total	90	84	89	43

[a] Case A represents a control case in which additional control measures beyond baseline are applied including fugitive dust control measures.

The average progress in Class I area counties nationally towards meeting these RH goals, measured in average deciview terms, for the two absolute illustrative progress goals is 81 percent for the 1.0 dv/10 years progress goal (1.0 deciview goal) and 90 percent for the 1.0 dv/15 years progress goal (0.67 deciview goal). For the two relative illustrative progress goals, the average progress in Class I area counties nationally is 65 percent for the 10% dv/10 years goal, and 81 percent for the 5 %/10 years goal.

Table 6-9 also shows the average deciview shortfall for the counties that do not reach the goal under Case A. For the 12 counties having Class I areas not achieving the 0.67 deciview goal after controls are applied under Case A, the region wide annual average deciview shortfall ranges from 0.06 to 0.15, meaning that on average these areas achieved from 0.35 to 0.44 (i.e., 70 to 88 percent) of the 0.5 deciview improvement needed to reach the goal. For the 19 counties having Class I areas not achieving the 1.0 deciview goal under Case A, the region wide annual average deciview shortfall ranges from 0.09 to 0.24, meaning that on average these areas achieved from 0.46 to 0.61 (i.e., 63 to 87 percent) of the 0.7 deciview improvement needed to reach the goal. For the 14 counties in Class I areas not achieving the 5% dv/10 years goal under Case A, the region wide annual average deciview shortfall ranges from 0.01 to 0.27, while for the 68 areas not achieving the 10% dv/10 years under Case A, the region-wide annual average deciview shortfall ranges from 0.01 to 0.58.

As mentioned in the preceding paragraph, while there are a number of counties that are not expected to meet the illustrative progress goals, many of these counties experience a substantial degree of visibility improvement. Most counties that are not expected to meet the RH progress goal are within 0.2 deciview of meeting them, indicating that many counties are close to meet these goals according to this report. There are several reasons why these counties are not predicted to meet these progress goals: 1) biogenic overestimation of VOCs in the west; 2) the partial attainment of the Ozone and $PM_{2.5}$ NAAQS is projected for 2015, not 2018, the date at which these goals are likely to be met; 3) technological progress is not considered; 4) the effect of Mexican and Canadian emissions on the control regions is not considered, and 5) superior innovative control strategies (e.g., emissions trading) is not in the control measures database.

Case B

Table 6-11 presents the number of Class I area counties that initially do not meet each illustrative RH progress goal and the estimated number of Class I area counties that are not able to meet the goals after additional control measures are modeled under Case B (with no fugitive dust controls included).

Table 6-11
Estimated Number of Class I Area Counties That Do NOT Achieve Illustrative

Regional Haze Progress Goals and the Average Deciview Shortfall Under Case B[c]

Region	1.0 Deciview Goal Over 15 Years (0.67 Deciview Goal)			1.0 Deciview Goal Over 10 Years (1.0 Deciview Goal)				5 Percent Deciview Goal Over 10 Years			10 Percent Deciview Goal Over 10 Years	
	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall	Baseline[a]	Post-Control[b]	Average Deciview Shortfall
Midwest/NE	0	0	--	0	0	--	0	0	--	1	1	0.09
Southeast	0	0	--	1	1	0.05	1	0	--	7	2	0.35
South Central	11	4	0.14	11	10	0.21	11	5	0.13	14	12	0.51
Rocky Mountain	21	3	0.10	27	6	0.18	26	3	0.18	30	29	0.39
Northwest	18	2	0.08	18	3	0.10	18	2	0.07	18	16	0.35
West	16	10	0.14	18	12	0.28	18	11	0.26	24	23	0.63
Nation	66	19	0.13	75	32	0.22	74	21	0.20	94	83	0.46

aBaseline represents class I area counties that do not achieve sufficient progress toward the illustrative progress goal after considering partial attainment of the $PM_{2.5}$ 15/65 standard and the 8-hour Ozone standard.

bPost-control represents counties that do not achieve sufficient additional progress toward the visibility goal after considering additional controls not already selected in the $PM_{2.5}$ 15/65 analysis.

C Case B represents an emissions control case in which additional control measures beyond baseline are applied that do not include fugitive dust control measures.

This table indicates that 19 of the 66 Class I area counties initially unable to meet the 1.0 dv/15 years goal cannot meet the goal with application of additional control measures under Case B, and 32 of the 75 counties initially unable to meet the 1.0 dv/10 years goal cannot meet this goal with application of additional control measures under Case B. This table also indicates that 21 of the 74 Class I area counties initially unable to meet the 5% dv/10 years goal can not meet this goal with application of additional control measures under Case B, and 83 of the 94 Class I area counties initially unable to meet the 10% dv/10 years goal can not meet this goal with application of additional control measures under Case A. The areas not able to meet these goals under Case B, as in Case A, are concentrated primarily in the west control region. Several of these counties are also not able to meet the illustrative progress goals in the baseline based on the results presented earlier in Chapter 6.

There are a considerable number of Class I area counties nationwide that are expected to meet the illustrative progress goals under Case B. The only exception is for the 10% dv/10 years goal. The percentage of Class I area counties nationwide that are expected to meet these illustrative progress goals is listed in Table 6-12. As indicated in that table, the percentage of Class I area counties that meet the illustrative progress goals ranges from 22 to 45 percent from benchmark to baseline, and ranges from 31 to 84 percent with the incremental control measures from baseline included. Consequently, there is a substantial amount of progress towards meeting the visibility goals in the benchmark and baseline as well as with application of incremental control measures.

Table 6-12
Percentage of Class I Area Counties That Meet the RH Illustrative Progress Goals in the Benchmark and Beyond Under Case B[a]

	Percentag e of Class I area counties meeting the 1.0 Dv/ 15 Years Progress Goal	**Percentage of Class I area counties meeting the 1.0 Dv/ 10 Years Progress Goal**	**Percentage of Class I area counties meeting the 5 % Dv/10 Years Progress Goal**	**Percentage of Class I area counties meeting the 10 % Dv/10 Years Progress Goal**
Benchmark to Baseline	45	38	39	22
Baseline to Incremental Control Strategies	39	36	44	9
Total	84	74	83	31

[a] Case B represents a control case in which additional control measures beyond baseline are applied but not including fugitive dust control measures.

The average progress in Class I area counties nationally towards meeting these RH goals, measured in average deciview terms, for the two absolute illustrative progress goals is 78 percent for the 1.0 dv/10 years goal (1.0 deciview goal) and 87 percent for the 1.0 dv/15 years goal (0.67 deciview goal). For the two relative illustrative progress goals, the average progress in Class I area counties nationally is 54 percent for the 10% dv/10 years goal, and 80 percent for the 5% dv/10 years goal.

Table 6-11 also shows the average deciview shortfall for the counties that do not meet the goal under Case B. For the 19 counties having Class I areas not achieving the 0.67 deciview goal after controls are applied under Case B, the region wide annual average deciview shortfall ranges from 0.08 to 0.14, meaning that on average these counties achieved from 0.36 to 0.42 (i.e., 72 to 84 percent) of the 0.5 deciview improvement needed to reach the goal. For the 32 counties having Class I areas not achieving the 1.0 deciview goal under Case B, the region wide annual average deciview shortfall ranges from 0.05 to 0.28, meaning that on average these areas achieved from 0.42 to 0.65 (i.e., 60 to 93 percent) of the 0.7 deciview improvement needed to reach the goal. For the 21 counties in Class I areas not achieving the 5%/10 years goal under Case B, the region wide annual average deciview shortfall ranges from 0.07 to 0.26, while for the 68 areas not achieving the 10% dv/10 years under Case A, the region wide annual average deciview shortfall ranges from 0.09 to 0.63.

As mentioned in the preceding paragraph, while there are a number of counties that are not expected to meet the illustrative progress goals, many of these counties experience a substantial degree of visibility improvement. Most counties that are not expected to meet the RH progress goal are within 0.2 deciview of meeting them, indicating that many counties are close to meet these goals according to this report. There are several reasons why these counties are not predicted to meet these progress goals: 1) biogenic overestimation of VOCs in the west; 2) the partial attainment of the Ozone and $PM_{2.5}$ NAAQS is projected for 2015, not 2018, the date at which these goals are likely to be met; 3) technological progress is not considered; 4) the effect of Mexican and Canadian emissions on the control regions is not considered, and 5) superior innovative control strategies (e.g., emissions trading) is not in the control measures database.

6.6 Cost Analysis Results

This section presents the annual cost of meeting the illustrative RH progress goals incremental to the 8-hour Ozone and $PM_{2.5}$ NAAQS baseline for this analysis under the control Case A (with fugitive dust controls included) and Case B (without fugitive dust controls). Under the structure of the final RH rule, the States are able to take into account costs for emissions reductions strategies in light of the degree of visibility improvement to be achieved. Therefore, high cost-control measures that have only minor effects on visibility can be avoided. For some Class I areas, there may not exist any cost-effective control measures that can be applied in the time period covered by this analysis. In addition, States have the flexibility to establish other reasonable goals and emissions management strategies. In these areas the incremental control costs (and also the benefits) of the final RH rule may be less than estimated in this RIA. Under such conditions, the incremental costs of the RH rule may be associated with administrative activities (e.g., planning, analysis, etc.) and Best Available Retrofit Technology (BART) controls for some establishments in certain source categories. The corresponding cost is estimated at $72 million (1990$). An explanation of this BART cost estimate is presented later in Section 6.6.3. It should be noted that for almost all eastern States a lower bound of zero for potential control costs associated with an illustrative progress goal is reasonable since virtually all Class I area counties are expected to meet these progress goals in the baseline. In addition, based on the control strategies selected by the Grand Canyon Visibility Transport Commission (GCVTC), the control costs may be lower than estimated in this RIA.

The presentation of incremental cost of the illustrative RH progress goals in this RIA is complicated by the residual nonattainment projected to exist for the analysis of the 8-hour Ozone and $PM_{2.5}$ 15/65 NAAQS which includes a modest version of the Tier II program described in

Chapter 5. An analysis that successfully models full attainment of the 8-hour Ozone and $PM_{2.5}$ standard should show reduced incremental costs associated with these illustrative RH progress goals compared to the estimates in this report in areas where there is significant overlap.

6.6.1 Results for Case A

Table 6-13 shows the total annual control cost of the illustrative RH progress goals incremental to the 8-hour Ozone and $PM_{2.5}$ NAAQS for Case A. The largest fraction of the incremental control cost is realized in the Rocky Mountain and Northwest regions. This seems logical since there are relatively few counties projected to be nonattainment for the $PM_{2.5}$ and Ozone NAAQS in the benchmark for these regions. Therefore, less control and accompanying visibility improvement are achieved in these regions in the baseline analysis.

Table 6-13
Regional Haze National Control Cost Summary -- Total Annual Cost for Illustrative Regional Haze Progress Goals[a] under Case A[b,c]
(millions of 1990 dollars)

Control Region	Baseline Visibility	1.0 dv/15 Years (0.67 Deciview Goal)	1.0 dv/ 10 Years (1.0 Deciview Goal)	5 % dv/10 Years	10 % dv/10 Years
Midwest/Northeast	0	0	0	0.3	380
Southeast	0	0.02	30	10	310
South Central	0	450	500	490	980
Rocky Mountain	0	260	620	440	960
Northwest	0	120	300	260	1,150
West	0	240	290	310	600
Nation	0	1,070	1,740	1,510	4,380

[A] Costs are incremental to partial attainment of the 8-hour Ozone and the $PM_{2.5}$ 15/65 standards. Totals may not agree due to rounding.

[b] Case A represents an emissions control case in which additional control measures beyond baseline are applied including fugitive dust control measures.

[C] These costs may be zero for States since they may choose less restrictive progress goals than those analyzed in this report. This is particularly true for States in the Midwest/Northeast and Southeast control regions since virtually all Class I area counties in these regions can meet most of the RH illustrative progress goals in the baseline for the RH rule.

6.6.2 Results for Case B

Table 6-14 shows the total annual control cost of the illustrative RH progress goals incremental to the Ozone 8-hour and $PM_{2.5}$ NAAQS for Case B. The largest fraction of the control cost, as in Case A, is realized in the Rocky Mountain and Northwest regions. This is particularly true for the 10% dv/10 years goal. This seems logical since there are relatively few counties projected to be nonattainment for the $PM_{2.5}$ NAAQS in the baseline in these regions. Therefore, less control and accompanying visibility improvement are achieved in these regions in the baseline analysis.

Table 6-14
Regional Haze National Control Cost Summary -- Total Annual Cost for Illustrative Regional Haze Control Costs[a] for Case B[b]
(million 1990 dollars)

Control Region	Baseline Visibility	1.0 dv/ 15 Years (0.67 Deciview Goal)	1.0 dv/10 Years (1.0 Deciview Goal)	5 % dv/ 10 Years	10 % dv/10 Years
Midwest/Northeast	0	0.3	0.3	0.3	310
Southeast	0	0.3	140	140	530
South Central	0	200	230	230	670
Rocky Mountain	0	270	450	330	640
Northwest	0	120	330	330	960
West	0	160	260	200	500
Nation	0	750	1,430	1,240	3,610

[A] Costs are incremental to partial attainment of the 8-hour Ozone and the $PM_{2.5}$ 15/65 standards. Totals may not agree due to rounding.

[b] Case B represents a control case in which additional control measures beyond baseline are applied without fugitive dust control measures included.

[C] These costs may be zero for States since they may choose less restrictive progress goals than those analyzed in this report. This is particularly true for States in the Midwest/Northeast and Southeast control regions since virtually all Class I area counties in these regions can meet most of the RH illustrative progress goals in the baseline for the RH rule.

The estimated nationwide annual control costs for the two RH alternatives analyzed previously in the 1997 RIA, the 1.0 deciview improvement and 0.67 deciview improvement goals, are now roughly half of the total nationwide annual control costs at proposal for Case A, and slightly more than half the total nationwide annual control costs for Case B. This difference is largely due to the inclusion of OC, EC, and fine particle soils in the RH optimization model. In particular, the optimization model now considers the contribution to visibility impairment from elemental carbon (U.S. EPA, 1999a).

While Case B has lower estimated total annual nationwide costs than Case A, it should be noted that there are more Class I areas that cannot meet the illustrative RH progress goals analyzed in this report. Therefore, quantitative comparison of these two control cases is not warranted due to differences in the number of Class I areas for the post-control air quality profiles are not similar. However, the results from applying Cases A and B do reflect the variability in results due to different assumptions regarding the highly uncertain aspects of the analyses. These differences in the results between the two emission control cases underscore the need for better information regarding emissions inventories, air quality modeling, and control strategy effectiveness.

6.6.3 Estimate of Potential Costs for the BART Element of the Regional Haze Rule

In consideration of compliance cost, performance of technology, existing pollution control at the source, and degree of improvement in visibility from further emission reductions, best available retrofit technology (BART) determinations are separate from yet related to other Clean Air Act programs. For example, if implementation programs designed to meet the NAAQS resulted in adoption of best available technology, there would not be a compliance cost impact from BART for affected establishments in those source categories. Likewise, if participation in the emission allowance trading program of Title IV of the Clean Air Act resulted in adoption of best available technology for SO_2 sources, there would not be a compliance cost impact from BART. For example, there are expected to be minimal compliance costs from controlling SO_2 for BART sources in the electric utility source category in the eastern States.

The BART determinations are developed concurrent with reasonable visibility progress goals and associated emission management strategies. Hence, where one assesses impact is somewhat uncertain. The assessments in this RIA include baseline control levels (from which visibility progress is measured in the first long-term strategy period), the incremental effects of establishing progress goals and emission management strategies independent of the BART process. To the extent, what would have been BART controls are reflected in the controls attributable to other Clean Air Act programs and the progress goal and emission strategy elements of the Regional Haze rule, the incremental control costs of BART are offset. However, there are incremental costs associated with the BART component of the Regional Haze rule. This is because the States have to do modeling and analysis as part of the BART determination process. Those costs are reflected in the total estimates for the administrative costs of the rule that are presented in Chapter 7 of the RIA. The administrative costs are $10 million (1990 dollars) in the 2015 analysis year. As explained in the paragraphs that follow, there may also be instances where there are some control costs for the BART component of the rule.

These candidates for BART-associated control costs are establishments that were built between 1962 and 1977 and that emit more than 250 tons per year of any visibility impairment precursor. Hence, they are a subset of the total number of establishments in the 26 source categories identified in Section 169(a) of the Clean Air Act. An estimate of the number of establishments in these 26 source categories that may incur controls under the 10% dv/10 year goal ranges from 425 (Case A) to 439 (Case B). These are establishments within these 26 source categories with pollutant emissions that are projected to impair visibility under the most stringent illustrative progress goal.   The resulting control cost estimate based on the control strategy model employed in this RIA is $1.5 billion in 2015 (1990 dollars) for up to the 439 establishments in those source categories under emission control cases A and B. The estimate of $1.5 billion is not an estimate of the BART element of the Regional Haze rule.

One reasonable way to assess the control costs associated with BART includes adjusting these costs based on looking at the difference between the costs for the most and least stringent illustrative goals (10 % dv/10 year and 1.0 dv/15 year), and making adjustments to account for the limited applicability of the BART for establishments within those 26 source categories. These latter adjustments are necessary to account for the age of process units, existing control technologies, and emissions trading possibilities. This BART cost estimation procedure is as follows:

1) Adjustment for age of establishment. 25 percent of the establishments are presumed in the 1962 to 1977 age category with other establishments being pre-1962 and post-1977. Hence, the control costs for the 425 (Case A) to 439 (Case B) establishments for the 10% dv/10 year goal and 1.0 dv/15 year goal are multiplied by 0.25. Consequently,

	10% dv/10 year	1.0 dv/15 year
Case A	$434 million	$57 million
Case B	487 million	125 million

2) Adjustment for existing controls. If the establishments are controlled for the 1.0 dv/15 year goal, the State is presumed to not come back to the source for a second time. The number of total establishments in these source categories under the 10% dv/10 year goal is again 425 for Case A and 439 for Case B. The number of establishments under 1.0 dv/15 year are 190 and 242, respectively. The associated adjustment factors would be 56 percent (235/425) for Case A and 45 percent (197/439) for Case B. Hence, the cost estimates would be reduced further. Consequently,

Case A	$211 million
Case B	163 million

3) Adjustment for emissions trading. Trading programs are likely to be used to further lower control costs for these large BART establishments. This would lower estimated control costs to 33 percent of the figures arrived at after imposing adjustment 2. This third adjustment is based on the experience of the EPA regarding the estimated costs for the SO_2 emission reduction allowance program prior to the Clean Air Act Amendments (CAAA) of 1990 compared to the realized cost of the program. The estimated cost savings of a trading program was $2 billion before the passage of the CAAA (i.e., $6 billion with command and control compared to $4 billion with

trading). The realized cost of the program, however, was $2 billion ($6 billion with command and control compared to the cost savings resulting from adoption of a trading program of $4 billion). Consequently, drawing on this experience, the command and control costs for BART should be decreased by 67 percent. This final adjustment would result in the following cost for BART sources:

Case A	$70 million
Case B	54 million

The total cost estimate must also include administrative costs. The average control cost estimate in 2015 is $62 million in 1990 dollars (($70 million + 54 million)/2). However, the BART cost estimate must also include administrative costs in 2015 of $10 million (1990 dollars) estimated in Chapter 7. Therefore, under these conditions, the estimated cost of the BART element of the Regional Haze rule is $72 million in 2015 (1990 dollars).

6.7 Analytical Limitations, Uncertainties, and Potential Biases

Because a quantitative uncertainty bound cannot be assigned to every input, the total uncertainty in the emission reduction, air quality, and cost outputs cannot be estimated. Nonetheless, the individual uncertainties can be characterized qualitatively.

Air quality projections to 2015 embody several component uncertainties, such as uncertainties in emission data, emission growth rates, baseline air quality data, and air quality modeling. These uncertainties are addressed in Chapter 4. The application of control measures and their associated costs are affected by the propensity of either the emissions projection methodology or the air quality prediction methodology to overstate or understate initial noncompliance in specific Class I areas.

As noted in Section 6.3, the optimization model annual cost inputs are in the form of average incremental cost per ton reduced. Even if these cost-per-ton estimates are adjusted to account for source size differences (as is done for some point source controls), these adjustments do not account for other important cost-determining variables, such as source status (new versus retrofit), annual operating hours, equipment, materials of construction, and unit prices for utilities, materials, and labor.

The least-cost optimization model also introduces a measure of uncertainty. For instance, when calculating the cost per average deciview reduced, the model does not count any emission reductions that are in excess of those needed to meet a specified visibility goal. This assumption could cause the cost per average deciview—and, in turn, the final control costs—to be overstated or understated, depending upon whether control of the precursor was beneficial.

Because a quantitative uncertainty cannot be assigned to every input, the total uncertainty in the emission reduction, air quality, and cost outputs cannot be estimated. Nonetheless, the individual uncertainties can be characterized qualitatively.

6.8 References

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